Form 406

U. S. DEPARTMENT OF AGRICULTURE

FOREST SERVICE

U. S. GOVERNMENT PRINTING OFFICE: 1932

3

ILLUSTRATED SUMMARY AND BRIEF DESCRIPTION

o f

PROBLEMS AND PRACTICE

i n
t h e

CHEMICAL SEASONING OF WOOD

---

2 U.S. Forest Service. 2a
FOREST PRODUCTS LABORATORY,
MADISON, ~~WISCONSIN~~

---

o

5c
Prepared 9/12/36.
WKL
C.W.T.
L.C.K.
C.C.P.

THE CHEMICAL SEASONING OF WOOD

INTRODUCTION

After 3 years of intensive work to develop a satisfactory method of drying planks, ties, and other larger items of species that defy the best known methods of air drying and kiln drying, the Forest Products Laboratory has worked out a new process that attains a freedom from seasoning defects heretofore thought impossible. The process is satisfactory for both softwoods and hardwoods. It is particularly applicable to the hardwood forests growing in the bottom lands of the lower Mississippi Valley, the profitable utilization of at least 25 percent of which is now largely prevented for want of adequate seasoning methods.

Items, such as wide flat-sawed plank cut from refractory hardwoods and large boxed-heart timbers which heretofore checked under the most carefully controlled drying conditions, can be seasoned by this process with little or no degrade. The drying time can, in general, be reduced well below that normally required in kiln drying.

The process, like most other new developments, has certain peculiarities of its own, some of which are advantageous, whereas others are deleterious.

Process Termed Chemical Seasoning

The process essentially consists of soaking green wood in an aqueous solution of some chemical, then removing it from the solution and subsequently air drying or kiln drying it. In the development of the process many items of lumber were soaked or steeped in various water solutions including sodium chloride (common house salt), mono-ammonium phosphate, zinc acetate, and several other chemical solutions. Several processes very satisfactory from the seasoning standpoint resulted from this work. These have been lumped together under the general head of "salt seasoning" or, more properly speaking, "chemical seasoning."

The Process Described

That common salt has the property of attracting moisture when stored in a damp place is common knowledge. Lumbermen taking advantage of this property have been known to sprinkle salt on checked lumber in order to attract moisture, dampen the surface of the lumber, and thus close the checks. Occasionally they have also sandwiched salt between layers of lumber in an air seasoning pile to reduce surface checking. Thus it will be seen that the use of salt in assisting in the drying of wood is not entirely new. The process is, rather, a more complete application of the knowledge of the properties of chemical solutions to the seasoning of wood.

In ordinary seasoning processes wood dries from the outside in, a fact which explains why wood so often checks in drying. When wood is properly chemically seasoned the wood dries from the inside first; that is, it dries from the inside out. If full advantage be taken of the chemical seasoning the surface fibers of wood are squeezed together throughout most of the drying period. Under these conditions it is impossible for wood to surface check in drying.

How Chemical Seasoning Works

The fundamental principles underlying chemical seasoning are very simple. It is a well known fact that when a chemical is dissolved in water the vapor pressure of the solution is lower than the normal vapor pressure of water. For example, the water-vapor pressure in an air tight space over a saturated solution of common house salt is approximately 75 percent of the normal vapor pressure of water. In other words, the vapor pressure of the brine is about three-fourths that of fresh water. In carrying out the process with a saturated solution of common house salt, the salt will diffuse from the brine into the water held by the green wood. Eventually the water in the wood will become saturated with salt and its vapor pressure will be in equilibrium with a 75 percent relative humidity. Therefore, as long as the relative humidity of the air surrounding the wood during subsequent seasoning does not become lower than 75

percent the water in the salt saturated layer of wood cannot evaporate. This layer of wood tends to retain its green dimension in spite of the fact that it is being subjected to a relative humidity as low as 75 percent, which, with untreated wood, would cause active drying and shrinkage.

In chemical seasoning, the green wood is soaked in the chemical solution just long enough for the salt to penetrate the outer surface of the wood. Consequently the water in the center of the board or plank, being fresh, has a normal vapor pressure; that is, the water in the center of a salt-treated green board or plank is 33 percent higher in vapor pressure than the salt-saturated moisture contained by the outer fibers. Moisture moves from the interior to the surface in response to this vapor pressure gradient and is evaporated. Thus , salt-treated green swamp oak plank, for example, can be safely dried in air having a relative humidity as low as 75 percent without surface checking, whereas when untreated it will commonly surface check in air having a relative humidity as high as 92 percent. The ability to use a drying atmosphere of lower relative humidity is reflected in increased drying rate and minimized seasoning degrade.

The process entails no actual chemical reaction between the wood and the chemical used but depends entirely upon the distribution within the moist wood of the original chemical with an accompanying gradual change in vapor pressure.

Green Wood Dries in the Salt Solution

At first it might be thought that the increased drying rate mentioned would be offset by the time lost while the planks are soaking in the salt solution. Experiments show, however, that the green lumber dries at the same rate while submerged in the salt and water it would in air maintained at bath temperature and a relative humidity in equilibrium with the vapor pressure of the solution. The rate of drying in the bath naturally depends on the chemical, on its degree of saturation, and on the bath temperature.

Scope of Experiments Thus Far

Salt seasoning methods thus far have been applied to ash bolts; small aspen half logs; beech squares; sections cut from large yellow birch logs; western red cedar poles and shingles; Douglas fir boards, planks, and timbers; hickory handles; southern swamp oak planks, dimension, and ties; persimmon golf head blanks; shortleaf and loblolly timbers, and redwood boards of sinker stock.

In most of the experiments either common house salt or mono-ammonium phosphate has been used, although a number of other chemicals, such as zinc acetate, invert sugar, borax, baking soda, and a combination of common house salt and sodium sulphate, have also been used.

Some of the experiments have been merely exploratory. The major chemical seasoning experiments demonstrated that all items tried could be dried more satisfactorily than they could be when dried by orthodox air seasoning and kiln drying methods.

TYPICAL SOUTHERN HARDWOOD STAND

Laurel and willow oak are probably the most thrifty hardwoods in the South Atlantic Coastal Plain. The trees grow rapidly yet are considered worthless because of the defects developing in seasoning. Salt seasoning offers a method whereby seasoning defects can be greatly reduced.

LOOKOUT TOWER

Modern wood structures using wood connectors must be seasoned to a moisture content suitable for use conditions with very little seasoning degrade in order to maintain high strength values.

Seasoning heavy softwood items requires time either in the dry kiln or air seasoning yard often resulting in a great deal of surface checking. Chemical seasoning offers an opportunity to dry heavy structural softwood timbers with lessened costs and reduced surface checking.

METAL LINED TANK USED AT THE FOREST PRODUCTS LABORATORY FOR THE TREATMENT OF GREEN WOOD WITH HYGROSCOPIC CHEMICALS.

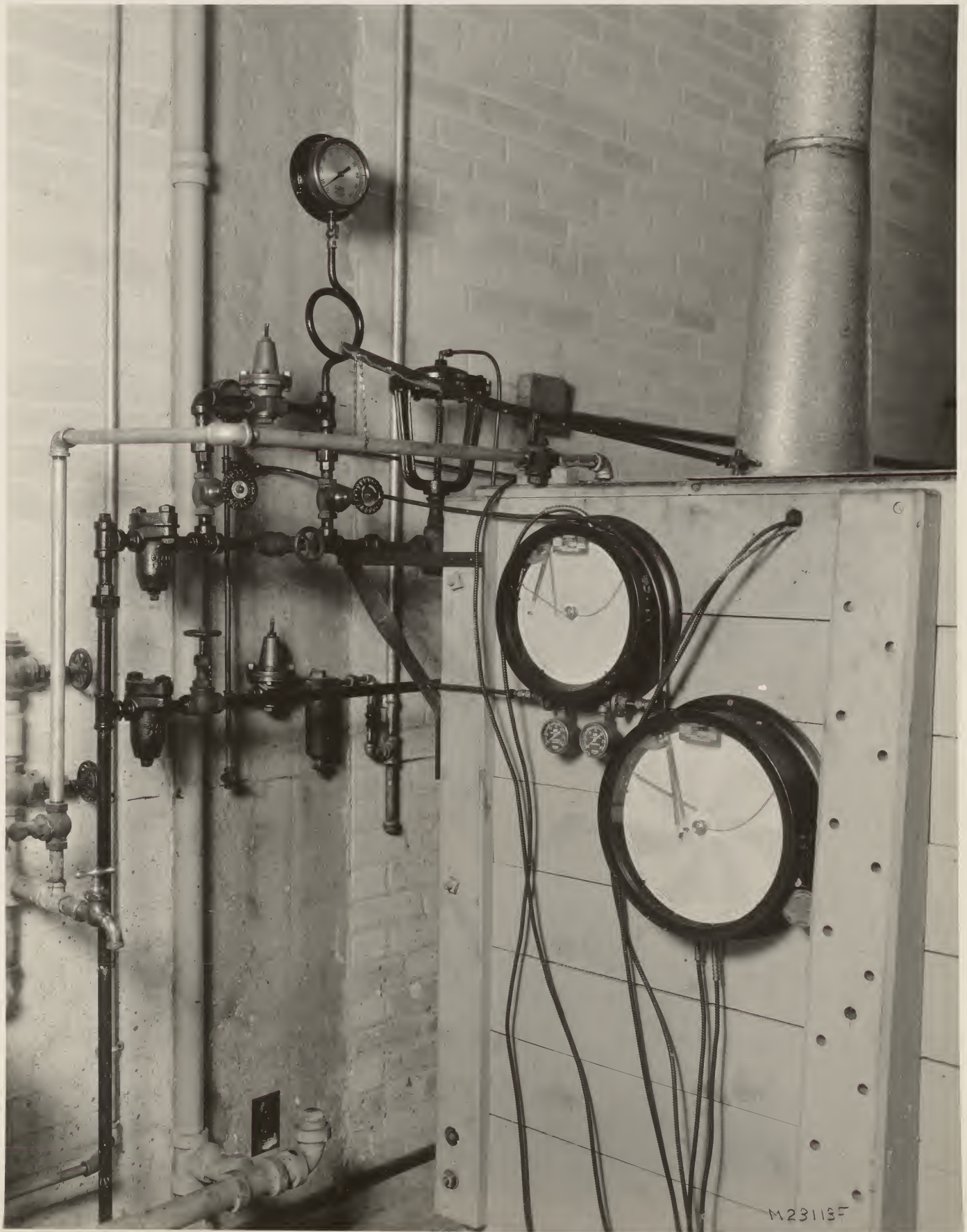
The chemical seasoning process consists of submerging the material to be treated in a solution of some hygroscopic substance such as ordinary salt (sodium chloride) or invert sugar and allowing this solution to diffuse into the green wood.

Tanks are used for this purpose, the chemical solutions being heated and agitated while the wood is submerged.


M2311F

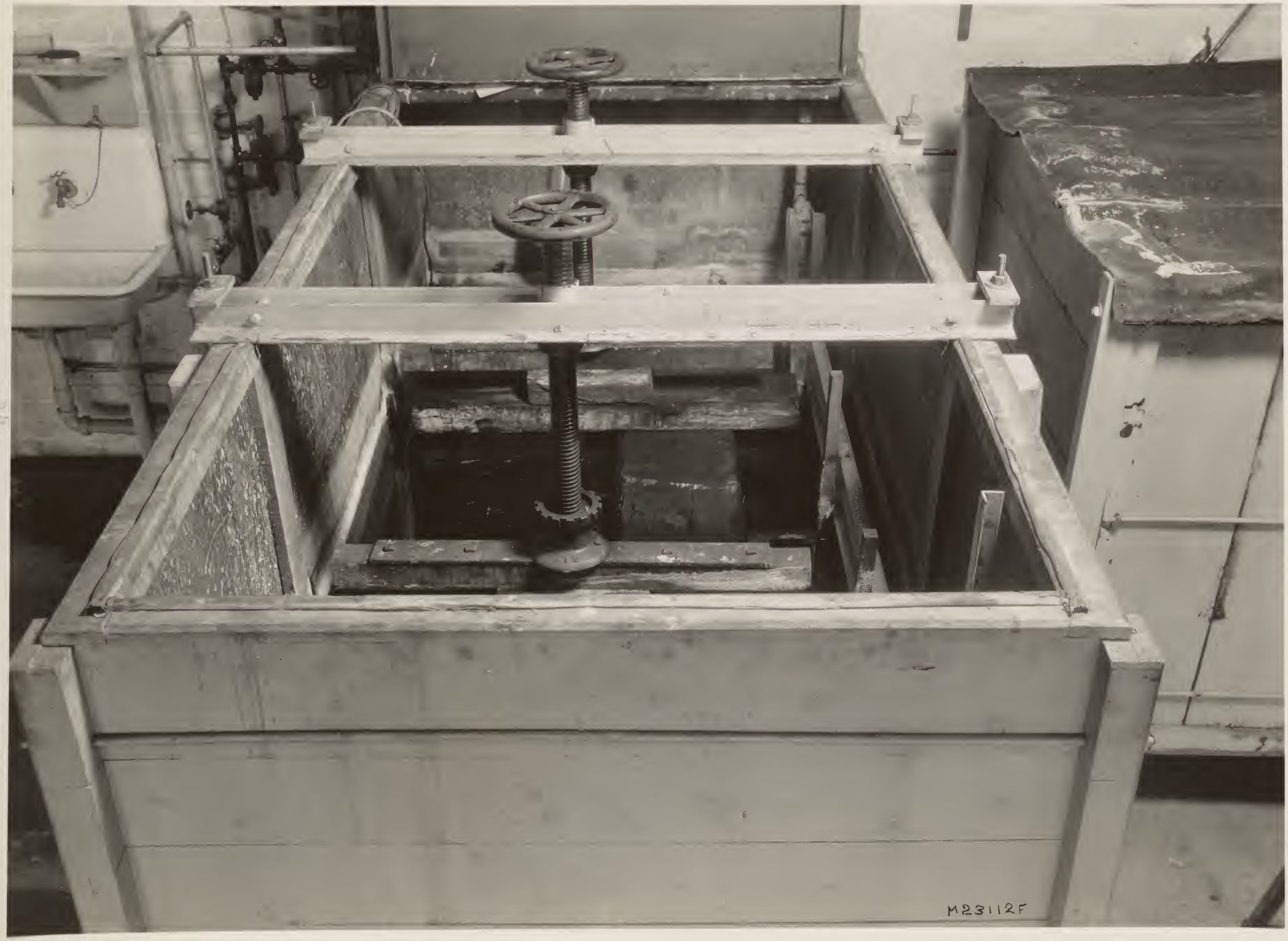
TEMPERATURE CONTROL AND TEMPERATURE RECORDING EQUIPMENT USED ON CHEMICAL TREATING TANK.

The chemical solutions are often heated in order to increase the rate of diffusion of the chemicals into the wood. This requires heating the solutions under automatic control using steam coils and modern control instruments. Moreover, by keeping the solution hot during the treatment it is possible to dry the timbers consideragly in the bath. The degree to which the solution may be heated varies with the item being treated or dried.


M23113F

METHOD USED TO SUBMERGE MATERIAL TO BE CHEMICALLY TREATED IN TREATING TANK.

The submerged material being treated must be held below the surface of the chemical solution. There are many ways that this can be done in the laboratory and in commercial operations.. We have pumped the chemical solutions into storage tanks while loading the wood to be treated in the treating tank and after loading pumped the solution back into the treating tanks.


M23112F

THE CHEMICAL SEASONING OF HARDWOODS

SURFACE CHECKING OF UNTREATED SOUTHERN SWAMP RED OAK.

Chemical seasoning is particularly applicable to the hardwoods growing in the bottomlands of the lower Mississippi Valley. A large percentage of this remains uncut or is lost during drying because of seasoning defects. Oak, which ranks first among hardwoods, is very refractory. It is estimated that 50 to 60 percent of swamp red and white oak is lost during seasoning and can be used only in small sizes such as flooring.

By chemical seasoning, 1-, 2-, and 3-inch southern swamp red and white oak have been kiln dried with practically no surface checking and with very little honeycombing. In air drying, also, checking and honeycombing were reduced greatly by the treatment.

In addition to this saving of material, the time in the kiln is greatly reduced. In a series of runs made with the view of getting the fastest drying time consistent with degrade green 1-inch oak was kiln dried to 10 percent moisture content in 17 days and 2-inch oak in 42 days including the time in the bath. Normal periods for kiln drying untreated 1- and 2-inch oak is of the order of 40 and 100 days respectively. Even with these longer periods of drying the untreated oak degraded badly in the kiln.

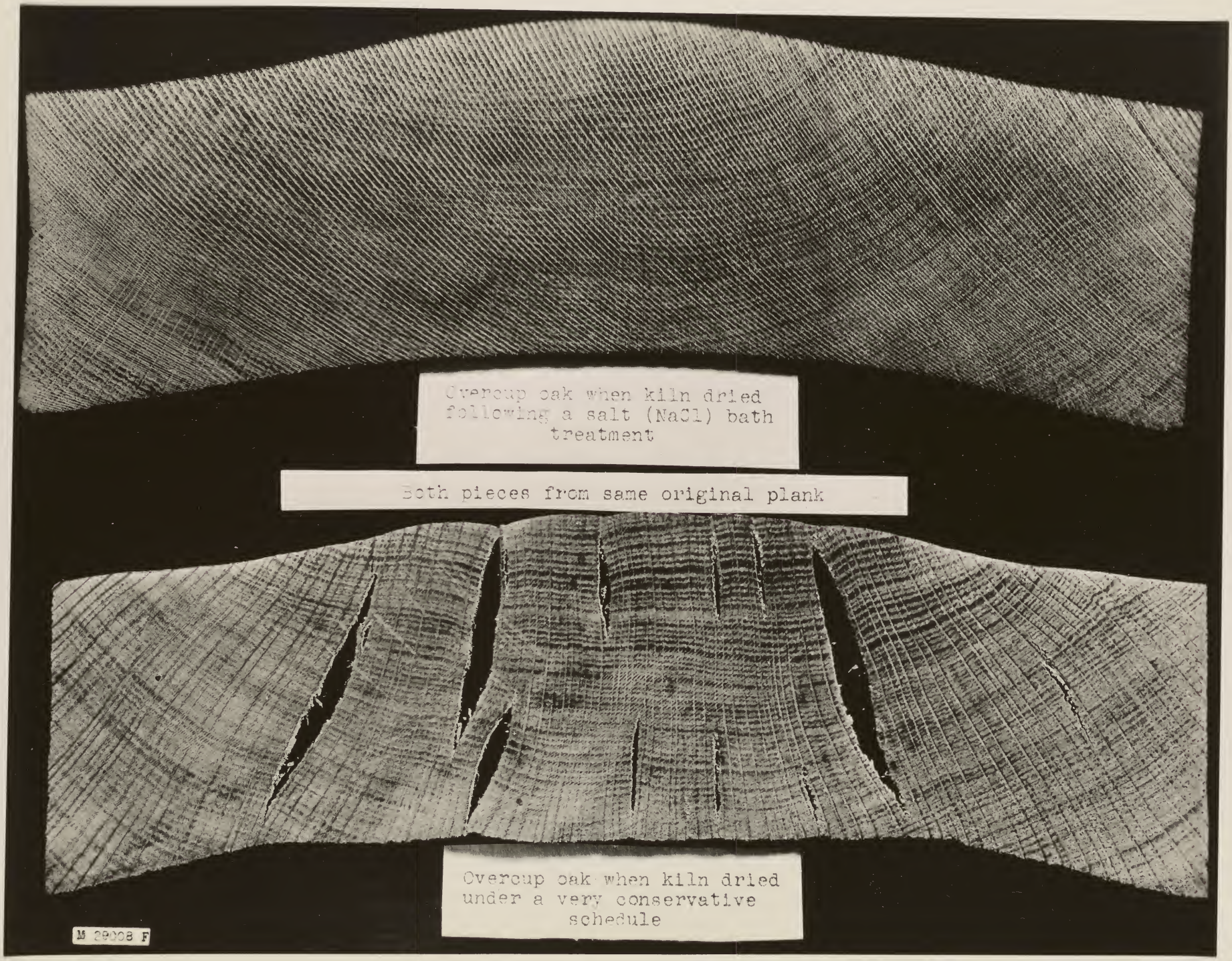
In air drying no saving in drying time is effected by chemical seasoning methods.

MATCHED PIECES OF 3-INCH OVERCUP OAK WHEN KILN DRIED UNTREATED AND WHEN KILN DRIED FOLLOWING A SALT (NaCl) BATH TREATMENT.

In air drying and even under the most conservative kiln schedules, southern swamp oak checks badly.

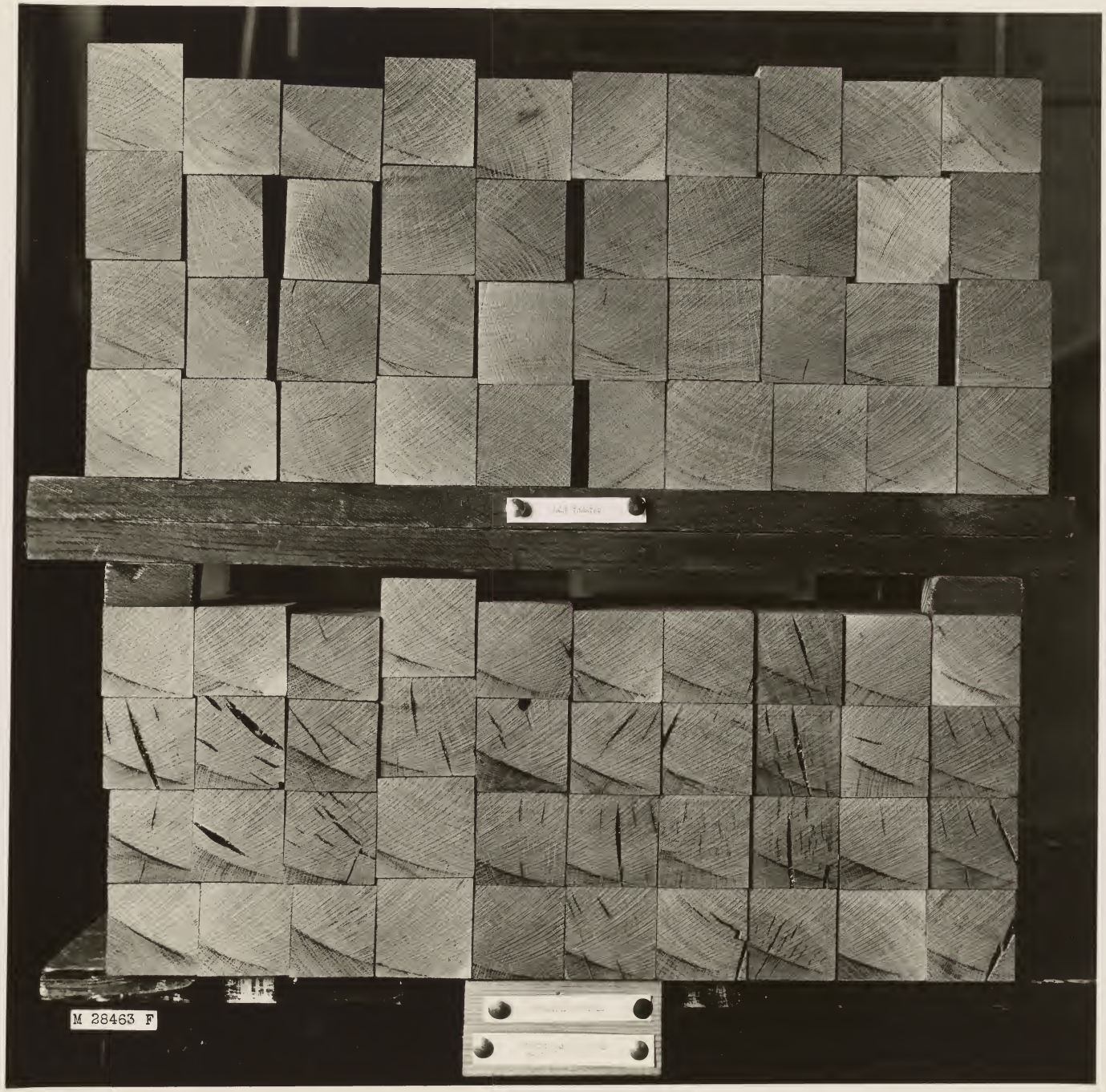
In the latter stages of drying, these surface checks extend into the interior and develop into honeycombing. The use of low temperatures and high humidities is not sufficient to prevent this.

Green wood when soaked sufficiently in a hygroscopic salt solution (common house salt for instance) absorbs enough of the salt to keep the surface damp and relatively free from tension stresses during drying, and under such a condition it is impossible for wood to surface check.


Overcup oak when kiln dried following a salt (NaCl) bath treatment
Both pieces from same original plank
Overcup oak when kiln dried under a very conservative schedule
M 29008 F

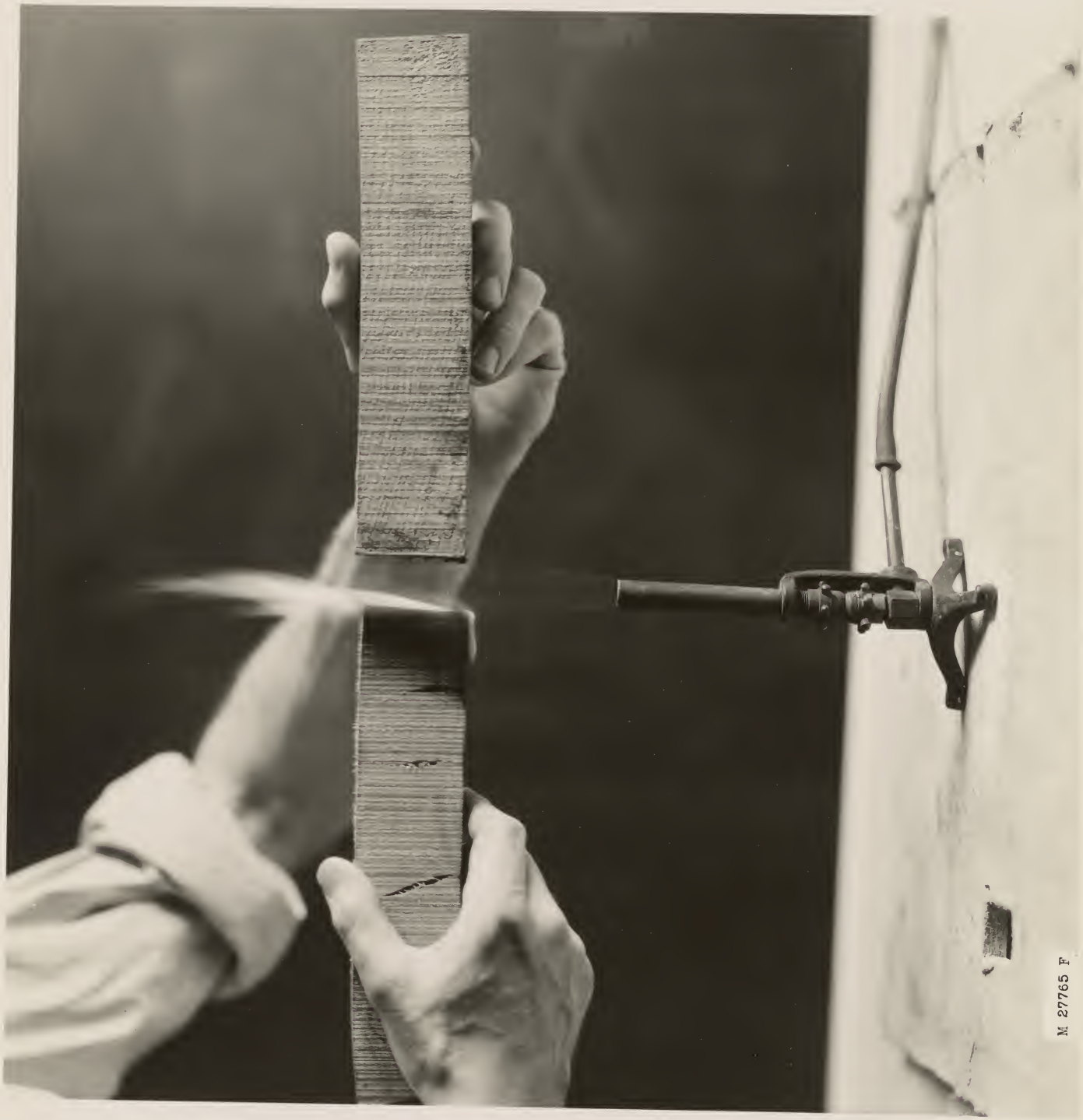
AN EXAMPLE OF TREATED AND UNTREATED OVER-CUP OAK SQUARES WHEN SEASONED EITHER AS SQUARES OR IN PLANK FORM.

As much of the hardwood lumber is used in some form of dimension stock the seasoning of this class of material is important. Through chemical seasoning sound turning squares of southern oak would be made available. Other forms of dimension stock would be correspondingly benefitted.


M 28463 F

MONO-AMMONIUM PHOSPHATE TREATED SOUTHERN RED OAK RESISTING HEAT FROM BUNSEN BURNER. THE PIECE ON LEFT IS AN UNTREATED CONTROL.

The soaking of green wood in an aqueous solution of a chemical is an easy way of obtaining a diffusion of the chemical in the wood. By using a suitable chemical, in the chemical seasoning process, fire resistant properties can be added to the wood.



M 27765 F

ASPEN BOLTS TREATED WITH A SOLUTION OF ZINC ACETATE AND KILN DRIED UNDER SEVERE DRYING CONDITIONS WITHOUT CHECKING.

The utilization of aspen will be increased as methods are developed whereby poles or bolts can be seasoned without serious checking resulting and at the same time its resistance to decay increased. The chemical treatment of barked aspen poles with a solution as zinc acetate which provides surface checking control even under most severe drying conditions will, at the same time, leave a water insoluble chemical in the wood, after it is seasoned and heat treated, that increases its resistance to decay.

The type of chemical used in the process can be selected according to the wood use requirements as well as provide surface checking control during the seasoning process. Toxicity and fire reduction can easily be made a part of the function of the seasoning chemical used.

SECTION OF YELLOW BIRCH APPROXIMATELY TWO FEET IN DIAMETER AND ONE INCH THICK CHEMICALLY TREATED WITH SODIUM CHLORIDE AND SEASONED WITHOUT CHECKING OR SPLITTING.

The seasoning of transverse sections of trees without the development of checks extending from the bark to the pith has always been a problem confronting exhibitors wishing to show a tree section as it was in the green state and to wood novelty manufacturers using whole tree sections in the production of various wood items.

With the development of chemical seasoning methods at the Forest Products Laboratory it is found that the process is applicable to the seasoning of tree sections as illustrated on the opposite page. This photograph shows a chemically treated and seasoned yellow birch tree section with the bark intact that was seasoned without checking or splitting. The method has possibilities of being adapted to other species through research.

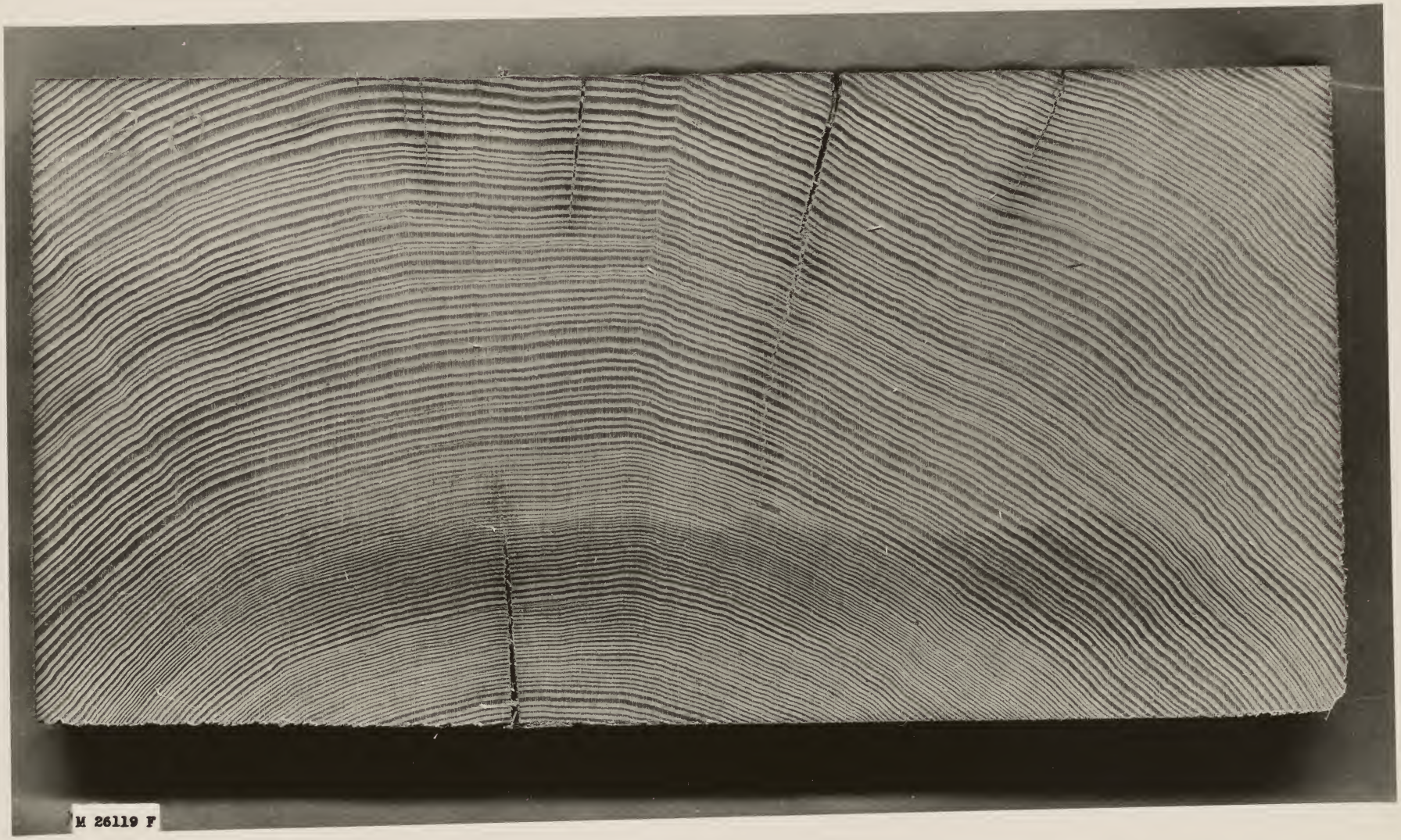
M 29038 F

THE CHEMICAL SEASONING OF SOFTWOODS

SECTION OF A 6 BY 12 INCH DOUGLAS FIR TIMBER AIR SEASONED AT MADISON, WISCONSIN. SURFACE CHECKS SUCH AS SHOWN HERE PARTICULARLY IF CONTINUOUS THROUGHOUT THE LENGTH OF THE MEMBER REDUCE ITS STRENGTH AS A BEAM MATERIALLY.

Structural timbers of the various sizes and species produced in this country are usually air seasoned or are used in the green condition with seasoning or drying taking place while in use. Whether drying takes place before or after being used as a structural member, the strength of the completed structure is impaired by the checking that inevitably takes place during the seasoning process.

It is believed that the chemical seasoning process applied to the seasoning of structural members offers a potential method of not only reducing the severity of the surface checking but of also reducing the time required to season to a moisture content suitable for proper fabrication.

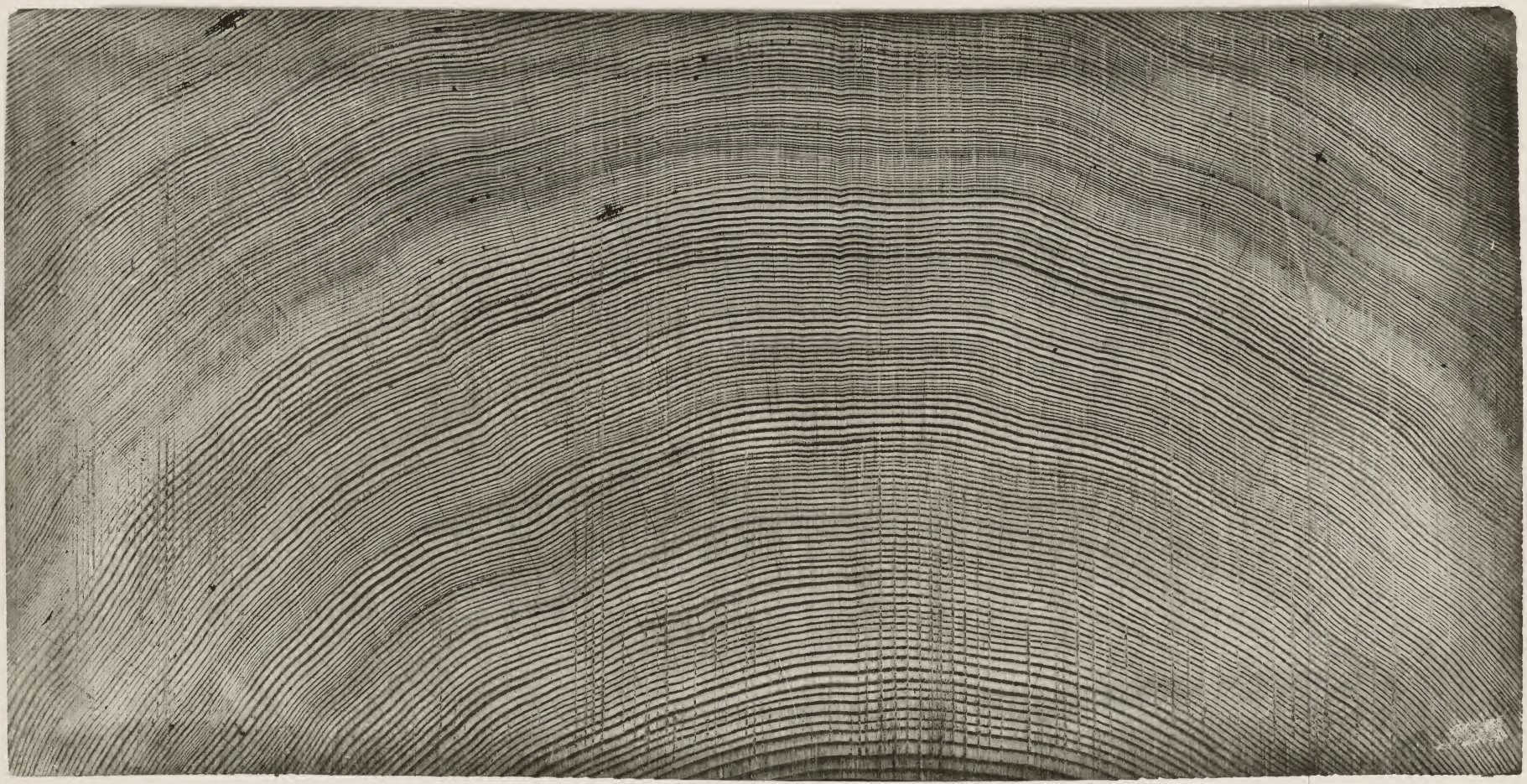

M 26119 F

TYPICAL 6 BY 12 INCH DOUGLAS FIR TIMBER AFTER BEING TREATED WITH A CHEMICAL SEASONING AGENT AND KILN DRIED TO A MOISTURE CONTENT OF ABOUT 16 PERCENT. COMPARE WITH PHOTOGRAPH ON PAGE 30.

The chemical treating process for the control of surface checking in softwood structural members is essentially the same as for the hardwoods previously illustrated.

The chemical used depends upon the chemical qualities desired, that is, whether or not toxicity or fire reduction is desired as well as surface checking control. With such woods as Douglas fir whose heartwood has such a low moisture content the diffusion of the chemical is very slow although sufficient penetration of the chemical can be obtained to obtain control of surface checking in subsequent kiln drying.

We have had excellent results with the chemical treatment and seasoning of such large items as 6 by 12 inch side cut Douglas fir, having been able to completely control surface checking and to also reduce the time required to season to a moisture content suitable for use.



M 26706 F

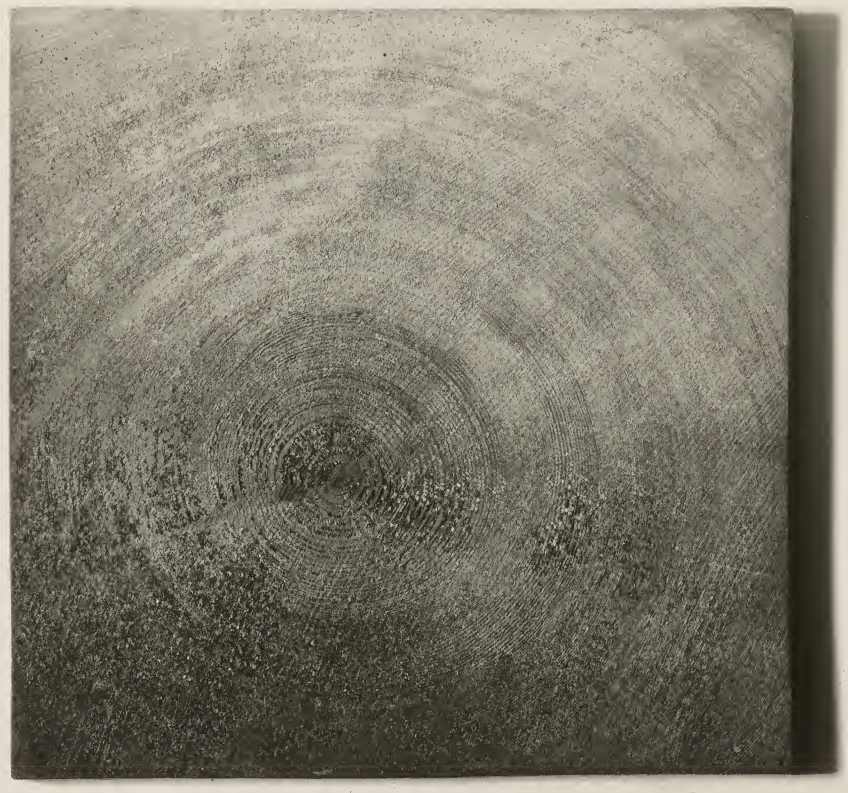
AIR SEASONED 12 BY 12 INCH DOUGLAS FIR HEART TIMBER SHOWING EXTENT OF CHECKING DUE TO SHRINKAGE RATIO. STRENGTH IS IMPAIRED FOR CERTAIN PURPOSES AND THE APPEARANCE IS DETRIMENTAL FROM A MERCHANDIZING STANDPOINT.

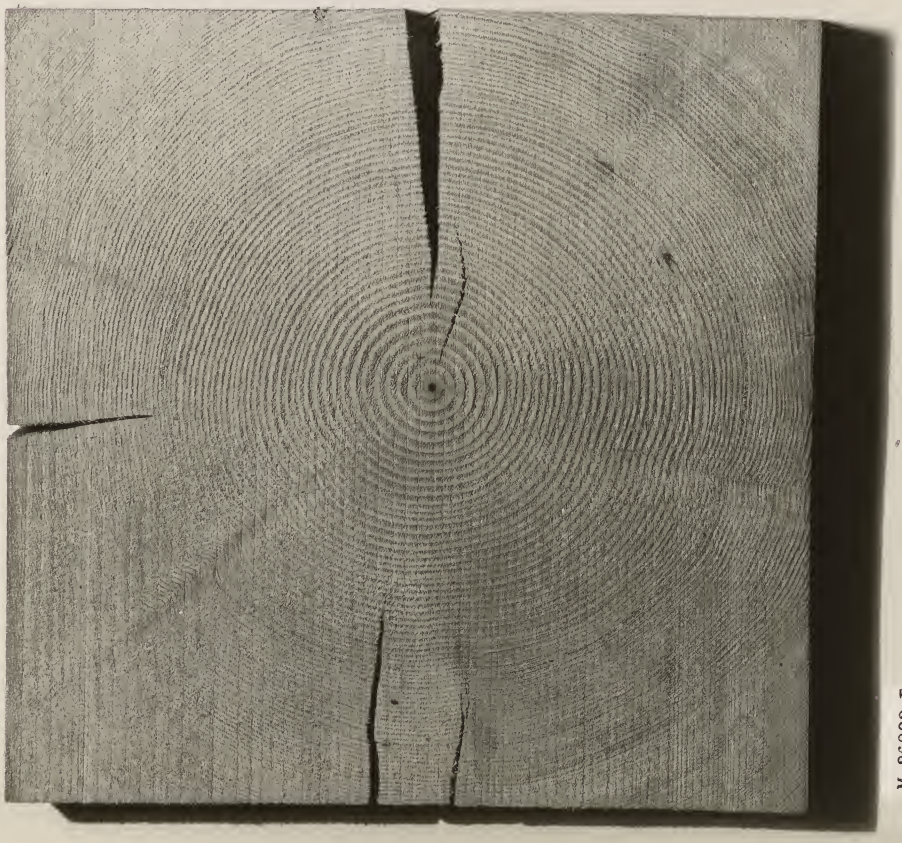
Boxed heart timbers and structural members check in seasoning because of the difference in tangential and radial shrinkage of wood. Ordinary seasoning methods cannot control this checking to the pith. It is quite possible, however, that the principles of the chemical seasoning process can be applied to completely control this checking as well as surface checking.

TWELVE BY TWELVE INCH BOXED HEART DOUGLAS FIR TIMBERS. THE CHECKED TIMBER IS AIR DRIED SHOWING THE EXTENT TO WHICH THE SHRINKAGE RATIO CAUSES "V" CHECKING. THE OTHER TIMBER WAS CHEMICALLY TREATED AND KILN DRIED TO AS LOW A MOISTURE CONTENT AS THE OTHER TIMBER WITHOUT CHECKING.

Large timbers such as these can be dried to a moisture content suitable for outdoor use either in the chemical solution or by first treating them in a chemical solution and then kiln drying them. The latter process is one of impregnating the green wood with a hygroscopic chemical by a diffusion process and then kiln drying at a condition which will not dehydrate the wood-water-chemical areas, yet allowing the interior treated portion to dry and shrink.

Our experience indicates that the process requires time although we have been able to obtain a fair control of "V" checking.





M 26902 F

A BADLY CHECKED TELEPHONE POLE IS UNDESIRABLE. THE CROSS ARMS MUST BE FREE FROM SURFACE CHECKS IN ORDER THAT THE INSULATOR PINS WILL NOT LOOSEN UP DUE TO SPLITTING BETWEEN THE PINS.

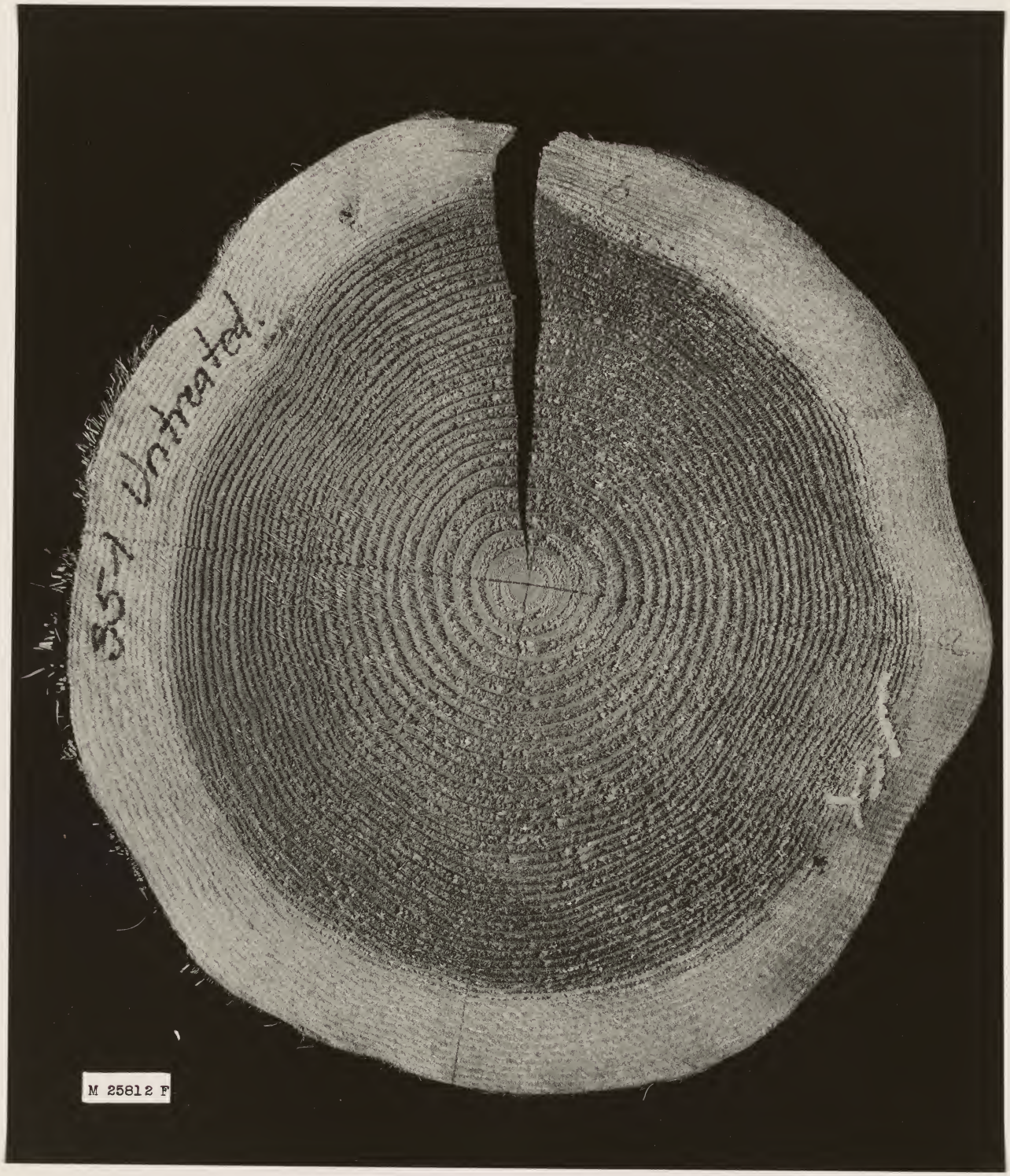
Telephone poles and cross arms have come in for their share of study insofar as chemical seasoning is concerned. Poles will check as they dry because of the shrinkage ratio reacting in an item including the pith. These checks are unsightly if large and tend to reduce the strength to some extent. Pole buyers do not like badly checked poles!

The seasoning of cross arms to a moisture content suitable for use without surface checking is desirable in order that subsequent trouble with insulator pins is avoided.

SECTION OF WESTERN RED CEDAR POLE WHICH HAS BEEN DRIED TO A LOW MOISTURE CONTENT. ORDINARY SEASONING METHODS ALWAYS RESULT IN SPLITTING OR CHECKING TO THE PITH.

When western red cedar poles are yarded for seasoning before impregnation with toxic materials, either in whole or butt treated, the resultant shrinkage causes the development of surface checks. These checks usually are distributed around the pole and none of them look particularly serious. If the shrinkage stresses were to loaclize in one place the resultant check would be as shown on the opposite page and if it were continuous the strength would be impaired. During drought conditions the excessive dryness prevailing causes extreme checking and splitting with great losses as pole buyers refuse to purchase badly checked poles.

Decay is also a hazard during the seasoning process as the sapwood of cedar is not particularly decay resistant.


85-1 Untreated.
M 25812 F

SECTION OF A CHEMICALLY TREATED AND KILN DRIED WESTERN RED CEDAR POLE SEASONED TO A LOW MOISTURE CONTENT WITHOUT SURFACE CHECKING.

Our experiments with western red cedar poles have been confined to the use of sodium chloride as the treating hygroscopic salt. Many disadvantages of such an electrolytic salt are overcome through the use of such a hygroscopic substance as invert sugar, the beneficial seasoning results available in either case. Our experiments also indicate that combined with the chemical treatment, kiln drying must be resorted to in order to gain complete control of surface checking.


Pale #1
M 27896 F

WESTERN RED CEDAR POLES WEATHERING AFTER BEING TREATED WITH SODIUM CHLORIDE AND KILN DRIED.

We have chemically treated and kiln dried two groups of western red cedar poles to an average moisture content compatible with use in Madison, Wisconsin. One group of poles was treated with a saturated NaCl solution and in kiln drying developed surface checks and blisters in which were found quantities of free salt. In weathering these checks closed up and even during unusually hot summer weather did not open up to an alarming extent. A second group of poles was treated in a 15 percent saturated NaCl solution, coated with aluminum paint and kiln dried with only one out of five poles checking. In weathering, however, these poles have developed fine or medium sized checks all around the pole. It is believed that the latter chemical treatment without painting but with higher relative humidities in the kiln drying can be used to produce kiln dried western red cedar poles for outdoor use that are not surface checked.

Plate 9

Western red cedar poles on end for weathering. Salt treated and kiln dried.

M 27903 F

DOUGLAS FIR CROSS ARMS 3-1/2 BY 4-1/2 INCHES IN SIZE. TREATED IN INVERT SUGAR AND KILN DRIED.

Many buyers of cross arms refuse to purchase anything but dry unchecked stock. The seasoning of Douglas fir cross arms is not particularly difficult, especially when kiln dried, but time is required.

Chemical treatment with hygroscopic substances allows kiln drying under more severe conditions, reducing kiln time yet controlling surface checking.

As the electrical insulating qualities of wood must be maintained invert sugar as a seasoning agent has great possibilities as it does not affect the electrical quality of the wood cross arm, yet enables rapid seasoning without surface checking.

PLANS FOR FUTURE WORK

Problems That Still Confront Us

In testing the theory of chemical seasoning and in working out certain fundamental details, such as diffusion rate as a function of concentration gradient, temperature, the moisture content of the wood; amount of chemical required to control the checking in various items; and the most severe drying schedules that can be safely used; we chose to use sodium chloride in most of our experiments. Salt was selected for the preliminary work because it was readily available and cheap and otherwise served our purpose very well. It was believed that any chemical that was sufficiently soluble in water and that tended to reduce the vapor pressure of water about as much as salt does could also be used. The hypothesis has been more or less verified by pilot experiments with other chemicals which have been mentioned elsewhere.

The deleterious effects of sodium chloride introduced into the wood by the treatment are at once apparent. Further, it is obvious that the degree to which salt will be troublesome will depend on where and how the wood is used.

Condensation

In common with all chemicals which control surface checks satisfactorily, the use of salt creates a condensation problem, i.e. in general chemically treated wood becomes damp on the surface at lower relative humidities than untreated wood does. When chemically treated wood is utilized for interior purposes the "condensation" problem largely drops out. It is conceivable, however, when used outdoors in damp climates that chemically treated wood will remain damp much of the time.

It is important that we learn the use conditions that make the condensation problem of practical significance. Research is necessary to discover whether the "condensation" problem can be satisfactorily overcome. Coatings, dressing away the chemically treated zones after drying, leaching the chemical out of the dry wood before use all suggest themselves as means of solving the problem.

Corrosion

A certain group of chemicals including sodium chloride are corrosive. When treated with any of these chemicals, planks or timbers under certain atmospheric conditions could naturally be expected to accelerate the normal rate at which metal fastenings rust. When used in bridges, towers, oil derricks in damp climates wood treated with corrosive chemicals may cause considerable trouble. We need to know the practical significance of this problem, i.e. we need to know whether connectors, bolts and nails rust away at a rate which makes the use of timbers treated with these chemicals impractical.

From the standpoint of economy of drying it would be desirable to use sodium chloride, but if its use creates a corrosion problem that cannot be readily solved we will have to discover the chemical that can be economically used for the purpose. Therefore, in future research work we should try out other likely chemicals which preliminary tests indicate to be non-corrosive. As in the "condensation" problem one naturally thinks of dressing off about 1/4 of an inch in order to remove most of the chemically treated wood.

Conductivity

The matter of electrical conductivity seems to be important when the chemically treated wood is used as poles or cross arms for example. Experiments should be made to determine whether the conductivity of items of this character is sufficiently increased to make the use of certain chemicals impractical.

Machinability

We have made some experiments to determine the effect of sodium chloride on woodworking tools. This problem should be studied more completely.

Solved and Unsolved Problems

We have come a long way toward an understanding of chemical seasoning and what can be accomplished by it. By chemical seasoning methods we know we can control seasoning degrade. Further, we know that we can dry any item that degrades in seasoning faster and better than it can be seasoned by any other known method. There are some unsolved problems in connection with seasoning of boxed heart timbers. We know the properties a chemical must have to be useful in salt seasoning. By choosing the proper chemical for the process we can impart to wood certain desirable properties and avoid the deleterious effect of corrosion and electrical conductivity. What we don't know is the practical importance of the deleterious effects. Neither do we know whether the shortcomings of certain chemicals when used in seasoning can be overcome for a reasonable amount. In addition to learning more about the various chemicals which seem to have the properties required for the seasoning process we need to know how and where chemical seasoning can be applied on a commercial scale. It may be necessary to work out the seasoning technique for each item and condition of use.